

May 28, 1998

L98-104

Harry McCarths

**(b) (6)**

Subject: Radiological Conditions at the Bluffs

Dear Mr. McCarths:

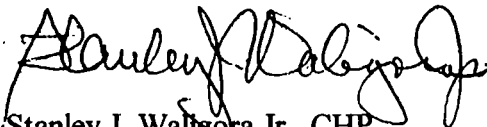
I am sorry that we could not get together during my visit to The Bluffs on May 19, 1998. The enclosed report describes the nature of radiological problems on improperly reclaimed lands. Section 6.0 is an assessment of the data we have at this time which is specifically related to The Bluffs. There is a definite radon problem in the community. Within two weeks Andrew Gross will install a number of radon monitors. The only data we have are four measurements taken by the Polk County Health Department. All were well in excess of concentrations that the EPA recommends for home mitigation.

In my nearly 40 years in this business, I have not witnessed anything like the wide spread problems over the five county area in central Florida. I have seen higher radiation levels but nothing approaching the size of the affected areas in Florida. You will notice from my enclosed resume that I have a great deal of experience in assessing and cleaning up radiation problems at government facilities. I can assure you that there would be a great deal of notorious public concern if residents adjacent to Dept. of Energy facilities were exposed to the levels found in communities built upon reclaimed phosphate lands.

I can understand the quandary presented to officials within the Florida Bureau of Radiation Control and the Polk County Health Department. The problem had its origins over 100 years ago. They inherited the problem areas and are not capable of coming to grips with what should be done. I attended a public meeting several months ago where one State official stated that they were not enforcing the radiation limits because they "felt" that they were too conservative.

Please feel free to request any information that might be helpful. I do hope that we can meet when I next visit. In the mean time, Andrew Gross and I will coordinate with Kevin Malone and Robert Erben to keep you informed as our investigations proceed.

Very truly yours,



Stanley J. Waligora Jr., CHP  
President



10518262

# **RADIATION EXPOSURE ON RECLAIMED PHOSPHATE LANDS**

by  
**Stanley J. Waligora Jr., CHP**

**May 27, 1998**

## **1.0 Introduction**

Central Florida has provided principle U.S. phosphate resources since 1888. For the first 20 years, floating barges were used to mine the Peace River bottom and embankments; wastes were disposed into the river. Land mining began in 1908 with the removal of overburden to reach the phosphate ores. Unacceptable ore fractions were placed back into the mined out pits or stored in above ground mounds. Ores within fine clays to not allow efficient production. This component is separated by sieving. Another component of the ore that yields poor production results is the insoluble sands. Starting in 1928, selective flotation was used to remove those sands. The two reject ore components are stored in clay storage ponds and sands tailings impoundments. For many years, these waste ores were allowed to accumulate. Some areas were reclaimed, but those practices were not always consistent with proper controls.

Slurry pipe lines are used to convey the phosphate ores to the production facilities. The fine clay waste slurries are only about five percent solids and some years must pass before the ore dries to about 20 percent solids that can be moved and stabilized by heavy equipment. Reclamation of the affected areas usually consists of spreading the wastes uniformly over an area. Because of the high liquid concentration, spreading is usually accompanied by creation of a central pond. Proper reclamation should include a substantial layer of non-waste overburden to isolate the radioactive and hazardous constituents from the surface environment. However, it is evident in some areas that insufficient cover has been placed over the waste ore.

## **2.0 Radioactive Constituents**

The natural conditions that created the phosphate ore deposits also created enhanced concentration of naturally occurring radioactive materials. Uranium co-exists with the phosphate ores. In the late 1970s, the price of uranium exceeded \$40.00 per pound and some of the Florida phosphate operations added a uranium recovery circuit.

The naturally occurring radioactive material consists of an array of radioactive isotopes that are within the uranium-238, uranium-235, and thorium-232 decay series. The uranium-238 series has 13 radioactive daughters, uranium-235 has ten radioactive

daughters, and the thorium-232 series also has ten radioactive daughters. Each of the daughters of the series have unique physical, chemical and radiological properties. However, a simple but realistic summary is that the radiations emitted from the contaminants have both penetrating and non-penetrating components. Gamma radiation is the penetrating component and can deliver a direct radiation dose by "shine" from contaminated surfaces. The non-penetrating emissions from contaminants deliver a radiation dose when those contaminants are internally deposited through ingestion and/or inhalation.

### 3.0 Radiation Exposure Pathways

Gamma radiation directly delivers whole body radiation dose. Gamma rays are similar to x-rays and are both penetrating and long-ranged in air. The greatest exposure occurs when the contaminants are in surface soil. Attenuation of the gamma radiation would be afforded by a sufficient cover of clean overburden. Some attenuation is also provided by a concrete slab beneath a building. The radiation dose can be measured at specific locations in a yard and within a home. The total radiation dose to individuals can be characterized by accounting for time spent at locations within the home, in the yard, and the time spent away from contaminated areas.

There are a number of different ingestion pathways. A principle concern is leaching of radionuclides to ground water. This can lead to direct ingestion of contaminated drinking water and can further lead to ingestion of foodstuffs contaminated by the groundwater. Crop roots can take in the radioactivity from soil and the scope of ingestion can extend to watered livestock and to fish consumed from ponds with contaminated sediments. Small quantities of soil are directly ingested through routine contact. Airborne contaminated dust can also deposit on produce.

Another dose path is the inhalation of airborne dust from suspended surface contamination. Wind can suspend that dust and tasks such as gardening and landscaping lead to increased inhalation exposure as well as that due to gamma radiation.

A specific concern is the presence of radium-226 within the uranium-238 decay series. In addition to the contribution to the dose pathways described above, radium-226 results in a unique kind of inhalation exposure. The first daughter of radium-226 is radon-222 which is a gas. Radon-222 gas seeps out of radium contaminated soil and is known to diffuse into homes and other buildings. Short half-lived radon daughters grow in at the rate of about 50 percent per half hour (75 percent within an hour). The daughters are characteristically airborne as very small particles which deposit efficiently on lung surfaces upon inhalation. For homes built on concrete slabs on radium-226 contaminated soil, the greatest source of radiation dose is likely to be inhalation of radon daughters. The importance of this source has been recognized in some Florida communities by

requiring that homes built upon reclaimed lands be elevated above the soil with sub-floor ventilation. This effectively prevents radon from diffusing indoors.

#### **4.0 Basic Radiation Effects**

Radiation effects depend upon the quantity and nature of radiation exposure. The radiation dose imparted to organs depends upon a number of technical factors. Certain tissues are more effected by radiation and the type and energy of the radiations qualify the effectiveness of the dose. For example, penetrating radiation deposits energy over a longer path through the body while the non-penetrating radiations have more intense energy deposition within an organ after inhalation or ingestion of those contaminants. The non-penetrating radiations are more effective in producing potential effects following internal deposition and retention.

A principle concern with long periods of radiation exposure is the possible alteration of chromosomes within cells. Some cells may die with no subsequent reproduction. Other cells may be altered in such a way that the altered state can reproduce as abnormal cells. The principle concern is for cells which are altered but which reproduce in that altered state. Reproduction of the altered cells can lead to the formation of cancer and of genetic defects. Whether radiation will cause cancer or genetic defects is a matter of probability related to the cumulative radiation dose. The higher the dose, the greater the probability.

Experience with higher radiation doses clearly demonstrates effects. This is known, for example, from the observed epidemiology of radium dial painters and of underground uranium miners. Extrapolating from higher dose effects to lower dose effects is difficult. One reason is that humans experience a relatively high incidence of cancer for other reasons and it is not possible to distinguish a specific cause. Roughly one-third of the population will experience cancer. In experiments and observations which have been analyzed to identify low dose effects, two different patterns have been observed. Some cancers appear to have a threshold effect; some minimum dose is required to pass the threshold of cancer induction. Other cancers seem to have no threshold and the extent of risk is proportionate to the dose regardless of how low. In establishing permissible dose limits the latter, and more conservative, assumption is used by international and national regulatory organizations.

## 5.0 Radiation Dose and Limits

As noted above, a complete explanation to the layman of the technical factors bearing upon definition of radiation dose units is not reasonable. However, a reasonable understanding is afforded by comparing dose "numbers" that are characteristic of the natural radiation background and of regulatory limits.

The average radiation background dose rate to the public, exclusive of radon daughter inhalation, is approximately 100 mRem/yr. The typical background dose rate from radon daughter inhalation is 200 mRem/yr. The generally accepted regulatory limit (excluding radon) for public exposure due to all sources of radiation dose in excess of background is 100 mRem/yr. Regulatory agencies recognize that there can be multiple contributors and pathways for radiation exposure and lower limits have been established to allow for other possible sources of radiation dose. Most of the limits have been selected because they are "do-able", protective of human health, and capable of assessment through routine monitoring. For drinking water, the EPA has established limits that correspond to a dose rate of 4 mRem/yr. For inhalation of airborne contaminants (excluding radon), the EPA limits the dose rate to 10 mRem/yr. Both the EPA and the U.S. Nuclear Regulatory Commission have been negotiating equivalent dose rates due to residual contaminants which remain following radiological clean ups. The EPA suggested residual concentrations equivalent to a limit of 15 mRem/yr. while the NRC suggested 25 mRem/yr. The EPA appears to have prevailed.

The Florida Regulations have essentially adopted the above radiation protection limits. Again, inhalation of radon daughters has required a separate consideration. The basic reason is that the background radiation dose for this path is relatively high. In addition, naturally occurring radium-226 concentrations can vary to the extent that homes require mitigation to decrease the risk of lung cancer even though the source is natural. Unfortunately, the radiation dosimetry associated with radon is rendered even more technically complex because the radon daughter concentrations are variable; only on site measurements can monitor the extent of actual daughter concentrations and the degree of variability with time and changing meteorological conditions. To relate the varying radon daughter concentrations to radiation dose a unit called the Working Level (WL) was defined. It was thought to be an acceptable level for occupational exposure in uranium mines; but continued observable effects required a lower limit. This unit corresponds to a given quantity of non-penetrating (alpha particle) energy liberated per volume of air. This allows for varying concentrations of alpha emitting daughters of different energies. The Florida Regulations specify that the background within buildings is taken to be 0.004 WL and that homes require mitigation at, or above 0.02 WL. Given the most typical expected daughter concentrations indoors, the latter corresponds to 4 pCi/L of radon-222. While not going into the attendant radiation dose, the level of 4 pCi/l is described here because radon testing results are usually presented in those units. In other words, the layman can review those results for comparison to the "magic number" of 4 pCi/L.

Another exposure limit given in various regulations, including those of the Florida Bureau of Radiation Control, is a gamma ray exposure limit of 20  $\mu\text{R/hr}$  inclusive of background.

## 6.0 Radiological Conditions in The Bluffs

The simplest and most accurate way to determine radiological conditions at any site is to take properly qualified specific measurements. These include measurements of gamma ray exposure rates and airborne radon concentrations. To date, limited gamma ray exposure rate measurements have been taken. Several outdoor measurements exceed the 20  $\mu\text{R/hr}$  regulatory limit, but better measurements and monitoring are required to qualify indoor levels. Several soil samples have been collected and are undergoing analyses for radium-226 and for all the other radionuclides present in the three identified decay series. Analytical results are used with mathematical models to estimate the total radiation dose received from all possible pathways.

The greatest concern is for elevated indoor radon-222 concentrations because of the slab on-grade construction. This is not the proper kind of construction for building upon reclaimed lands. As noted earlier, sub floor ventilation has been used in other communities to prevent radon from entering homes. Informal communication with a local agency showed they had measured levels of 10 to 28 pCi/L of radon-222 in homes within The Bluffs. This ranges from twice to seven times the limit specified for mitigation.

Homes within The Bluffs can be mitigated to reduce indoor radon concentrations. The most likely method is to dig beneath the concrete slab to establish ventilation paths. These are connected to vent stacks equipped with fans. Instead of diffusing into the home the radon will be vented through the stacks. If the soil beneath the concrete does not permit effective diffusion of radon to a stack, more ventilation paths and stacks are constructed. Along with this ventilation, mitigation includes sealing of the concrete slab from within the home.

There are two ways to summarize the extent of health risk presented by the elevated radon concentrations within The Bluffs. Florida regulators have assumed a natural radon background of about 0.8 pCi/L. Thus 10 pCi/L is 12.5 times background and 28 pCi/L is 35 times background. From the adult uranium miner epidemiological data, there is a risk of one death per 10,000 people per year per pCi/L of radon; 10 per 10,000 at 10 pCi/L. In other words the odds are one chance in one thousand at 10 pCi/L and 2.8 chances in one thousand at 28 pCi/L. These risk probabilities are based upon adult epidemiology. The dose to infants and children require special consideration. Long term residence at levels of 10 to 28 pCi/L is not an acceptable risk.

**Plans for the immediate future are to perform additional gamma ray measurements with both portable instruments and passive environmental monitors to establish those levels. Radon test kits will also be used to screen for elevated indoor concentrations.**

**Finally, experts will be made available to answer questions and to explain the monitoring and measurement results.**

**EXHIBIT A Curriculum Vitae**

**STANLEY J. WALIGORA JR., CHP**  
Principle Health Physicist and President  
Environmental Dimensions, Inc.

**QUALIFICATIONS SUMMARY**

Mr. Waligora has over 38 years of diversified experience as a health physicist. His experience has included training, applied health physics and industrial hygiene, medical physics, radiobiological research, environmental monitoring and assessment, radiochemical analysis, environmental restoration, decontamination and decommissioning, radioactive and mixed waste management, and a broad scope of related consulting projects. Services have been provided to DOE contractors, nuclear utilities, nuclear fuel plants, uranium mills, and to other government, medical and industrial facilities. He has over 25 years experience in remedial action and associated waste issues. He has prepared over 100 environmental surveillance reports related to nuclear testing, nuclear utilities, nuclear fuel plants, uranium resources companies, and for various other government and industrial facilities. Mr. Waligora has been selected to serve on a number of government and standards committees including ANSI Standards for internal and external dosimetry, and the EPA Safe Drinking Water Act..

More recent project experience includes:

Technical support for compliance to new DOE Orders and regulations, EPA Regulations, and TSA and Tiger Team audits.

NEPA, CERCLA, NESHAPS and RCRA integration and compliance.

Evaluation and environmental risk assessment of naturally occurring radioactive materials in oil, gas, and mineral production facilities.

Environmental, health physics, and radiochemistry laboratory audits for a number of DOE prime contractors.

Design and implementation of mixed waste analytical laboratories for government and commercial facilities.

Radioactive and mixed waste management strategies for government and industrial facilities.



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## **CERTIFICATIONS**

American Board of Health Physics-General Practice (Since 1968)

U.S. Public Health Service Laboratory Director for Radiobioassay (Since 1973)

NM Environmental Improvement Division Registered Qualified Expert Registration No. 108-8  
(Since 1980)

## **EDUCATION**

1959                Siena College, B.S. Physics  
                      (N.Y. State Regents Scholarship and Sienna College Tuition Scholarship)

1967-71           University of New Mexico  
                      Part time graduate studies in Physics and in Business Administration

## **EMPLOYMENT HISTORY**

1990-Present        **President**  
                          Environmental Dimensions, Inc.  
                          Albuquerque, NM

He founded EDI in January, 1990 and has supported and directed a broad scope of projects for various clients.

Since its inception, EDI has been providing support at the DOE Fernald Environmental Management Project through a series of six continuing contracts. Technical support has been provided to achieve a broad scope of CERCLA regulatory and technical requirements for the RI/FS and associated Consent Agreements and Consent Decrees. Related activities have included NEPA compliance and RCRA integration. Action plans have been reviewed in response to TSA and Tiger Team audits. EDI has provided a number of complete Removal Site Evaluations, with pathways analysis and risk assessments, and has assisted in review of the attendant EE/CAs and CMRs. Participation in the RI/FS activities has included sampling and analysis plans, the Quality Assurance Project Plan, and a number of specific tasks to implement features of those plans. A major accomplishment was an extensive dose-risk assessment for D&D of the Production Area including decommissioning of over 200 facilities within the 136 acre area. This assessment estimated the consequence of releases and of extensive radioactive

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waste shipments. An Interim Record of Decision allowed the D&D to start two years ahead of schedule.

EDI is also providing technical and professional support for radioactive and mixed waste management. Tasks have ranged from drafting program plans to specific operating procedures. Generic and specific sampling and analysis plans have been provided, along with the QAPjP, with emphasis upon applicable waste acceptance criteria. Assistance has been provided for specific Waste Disposal Applications.

Current support to the environmental monitoring program includes procedures and implementation of analytical systems ranging from gamma spectrometry through tritium species air sampling. Additional support includes sensitivity analysis for ALARA public exposure assessment and preparations for 10 CFR 834 compliance.

Another multi-year project was third party oversight for a uranium mill restoration. The emphasis was on demonstrable documentation of all tasks related to both regulatory compliance and adherence to site specific commitments through the NRC License and the extensive Restoration Plan. EDI assured documentation of all details related to QA/QC ranging from instrument calibrations through validation of vendor laboratory analytical results. Specific additional emphasis was placed on applied health physics with appropriate programs for air sampling, personnel dosimetry, ALARA, and changes necessary to meet the new 10 CFR 20 requirements.

EDI conducted a turnkey remedial action for a formerly licensed facility. The complete initial Characterization Work Plan covered a 40,000 ft<sup>2</sup> building, sewer lines, and adjacent land areas. The characterization was completed following review and approval by the NRC and the State. The Characterization Report was followed by a similarly approved Remedial Action Work Plan and the cleanup proceeded. A final report was approved by the state and the NRC, and the site was released for uncontrolled use. The Waste Profile was completed and resulted in disposal at the Envirocare LLW site in Utah.

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A broad scope of shorter term tasks have been completed by EDI. Examples include:

- Sampling procedures for airborne particle size distributions.
- Technical and QA audits of commercial and government contractor radiochemistry laboratories and health physics programs.
- Design of mixed waste analytical laboratories
- Peer reviews of critical instrumentation systems.

**1989        Senior Program Manager**  
Geoscience Consultants, Ltd.  
Albuquerque, NM

Program manager for radiological environmental projects. Primary project was RI/FS support at a plutonium contaminated DOD site.

**1972-89     Facility Manager (then) Technical Director**  
Eberline Analytical Corporation  
Columbia, SC to Albuquerque, NM

Joined Eberline Instrument Corp. to build, staff, and manage the Southeastern Facility in Columbia, SC. Primarily a radiochemistry laboratory with radiation dosimetry, instrument calibration and maintenance, and instrument sales for southeastern U.S. Also responsible for business development. Reputation for quality work with rapid turnaround. Consulting in environmental programs, internal dosimetry, and medical physics. Prepared over 60 environmental reports for nuclear utilities and nuclear fuel plants including pre-operational summaries and annual assessments. Original work in radiochemical procedures. Shielding integrity project (to 14 ft. concrete) for a reprocessing plant under construction. Designed and established an environmental analytical laboratory in Spain. Member of the SC Technical Education Committee for five Centers providing Associate Degrees in Nuclear Engineering Technology.

Promoted and transferred back to NM in 1977 to become Technical Director for the Nuclear Services Division.

Provided technical direction and business development for health physics services, radiochemical analyses, and external radiation dosimetry. Significant consulting and field work for governments and industry in radiological assessments and remedial actions. Early work for uranium mills and solution mining operations permitted effective solutions to problems

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associated with naturally occurring radioactive materials. Services for the latter were provided to oil and gas, phosphate, rare earths, geothermal, and other extractive industries. The diverse consulting practice included work for manufacturers of radium bearing building materials, users of a large pulsed x-ray machine, and attorneys and physicians for radiation dose assessments. Through applied research, he developed a six element radiation dosimetry badge capable of distinguishing shallow and deep doses in mixed radiation fields. Assisted in the initial setup and calibration of the detector system for a soil sorter for use in the South Pacific (Enewetak Atoll and Johnson Island).

**1967-72      Chief, Health Physics and Industrial Hygiene**  
Inhalation Toxicology Research Institute  
Lovelace Foundation  
Albuquerque, NM

Responsible for occupational and environmental controls for research with radiological and non-radiological intoxicants along with laboratory safety. Radiation dosimetry assistance to principal investigators. Close work with Aerosol Physics Dept. Developed an effective cascade centripeter (virtual impactor) for airborne particle size distributions. Operated whole body counter (fission and activation products) and worked with Los Alamos for transuranic isotopes. Active in other DOE-ALOO work at Rocky Flats and G.E.-Pinellis (FL). Assisted in the first bronchopulmonary lavage for accidentally inhaled radioactive material. Clinical duties in Radiology at Lovelace Medical Center including therapy planning, calibration, and treatment. Taught math and physics to Radiology residents for Board Exams. Out-sourced to support D&D of a 150,000 ft<sup>2</sup> special nuclear fuel plant near Baltimore, MD.

**1966-67      Health Physicist**  
Reynolds Electrical & Engineering Co., Inc.  
Nevada Test Site  
Mercury, NV

Responsible for all applied health physics and industrial hygiene support for Lawrence Livermore Laboratory tests. Special projects in training, radioiodine monitoring, permissible levels of short half-lived radionuclides, and tunnel abatement of gaseous Ru-Rh-106. Design of new radiological facilities.

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**1964-66      Health Physicist (then) Chief, Data Processing**  
U.S. Environmental Protection Agency (PHS)  
Las Vegas, NV

Field Monitoring and environmental report writing for first 10 months. Data Processing supported data reduction for radiochemical analysis, environmental monitoring, whole body counting, and for radiobiological research. Supervised reorganization of this section and rapid hardware improvements (IBM 1620, SDS-925, CDC-1604). Helped prepare and teach the first Associate Degree program in X-Ray Technology (medical) at the University of Nevada-Las Vegas.

**1962-64      Training Supervisor**  
Radiological Sciences Dept.  
Reynolds Electrical & Engineering Co., Inc.  
Nevada Test Site  
Mercury, NV

Technical and professional training in health physics and industrial hygiene. Developed and implemented a two-year training program for site technicians which became part of their Union Contract. Significant external training in Radiological Emergency Operations and other contracted AEC training for non/NTS personnel. Filled in as Radiological Safety Shift Supervisor. Special projects. Whole body counting liaison with EPA for routine and accident dosimetry.

**1959-62      Nuclear Weapons Officer-Instructor**  
U.S. Army Defense Nuclear Agency (DASA)  
Kirtland (Sandia) Base  
Albuquerque, NM

Taught nuclear weapons and health physics to nuclear emergency teams. Major work at Nevada Test Site. Co-authored basic texts. Produced technical manuals, training films, and other training aids. Performed tritium bioassay analyses. Specialized in radiation detection instruments and biological effects of radiation. Course Supervisor for several programs and was Radiation Safety Officer for AEC By-product License.

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## **PUBLICATIONS AND PRESENTATIONS**

"Dose Reconstruction at a NORM Site," 29<sup>th</sup> Midyear Topical Meeting of the Health Physics Society, Scottsdale, AZ, 1996.

"Dose and Risk Assessment for the Fernald D&D Project", American Nuclear Society Decontamination and Decommissioning Conference, Washington, D.C., 1994 Co-authors: John Throckmorton, Todd Clark.

"A Six Element Dosimetry Badge for Beta and Photon Spectrometry", Second Conference on Radiation Protection and Dosimetry, Orlando, FL, 1988.

"External Radiation Dosimetry at Nuclear Power Plants", 21st Midyear Topical Symposium, Health Physics Society, Miami, FL, 1987.

"Fundamentals and Current Directions of Solid State Dosimetry", Professional Enrichment Program. Health Physics Society Annual Meeting, Salt Lake City, UT, 1987.

"Pre-Operational Radiological Environmental Monitoring - Answers and Questions", Health Physics Society 19th Midyear Symposium, Colorado Springs, CO, 1985.

"Applied Neutron Spectrometry and Dosimetry", Health Physics Society, Rio Grande Chapter, Los Alamos, NM, 1985.

"Remedial Action Experience", EPA Region VII Conference, Lincoln, NE, 1982 (Invited).

"Instrumental and Radiochemical Assessment of Decontamination Operations", Health Physics Society Annual Meeting, Las Vegas, NV, 1982. Co-authors: Leon Leventhal, Robert Wessman, and Richard Powell.

"New Concepts in Radon and Radon Daughter Measurements", International Conference on Radiation Hazards in Mining, Golden, CO, 1981. Co-authors: Richard G. Terry and Rex Beard.

"Eberline's New Microcomputer Based Radon Daughter Instrument", International Symposium on Indoor Air Pollution, Health and Energy Conservation, Boston, MA, 1981. Co-authors: Eric L. Geiger and Rex Beard.

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"Uranium Monitoring", "Operational Experience on Uranium Monitoring", and "Operational Experience on Radon Monitoring" (Invited), Summer School on Uranium Health Physics, South African Association of Physicists in Medicine and Biology, Johannesburg and Pretoria, South Africa, 1980.

"Neutron Monitoring and Dosimetry at Nuclear Power Plants", Health Physics Society Annual Meeting, Seattle, WA, 1980.

"Neutron Dosimeter Calibration at Nuclear Power Plants Through Instrument Surveys", American Industrial Hygiene Conference, Chicago, IL, 1979.

"Radiochemistry" Chapter in Quality Assurance for Health Laboratories, American Public Health Association, 1978.

"Pre-Operational Baseline Data - Methodology Used in Environmental Surveillance", Southeastern Seminar on Environmental Radiation Surveillance, Montgomery, AL, 1974.

"Pulmonary Retention of Zirconium Oxide (Nb-95) in Man and Beagle Dogs", Health Physics, 1971. Co-author: Chester R. Richmond.

"Safety Aspects of Research with Respirable Radioactive Aerosols", Radiation in High Level Facilities (IAEA), Saclay, France, 1970. Co-author: J.A. Mewhinney.

"Incineration of Solid Wastes", Solid Waste Disposal Symposium, Defense Nuclear Agency, Albuquerque, NM, 1970.

Off-Site Survey Operation Roller Coaster, U.S. Public Health Service, 1969. Co-authors: J.S. Coogan and D.L. Waite.

"Incineration of Low Level Radioactive Wastes", 4th ALO Health Protection Conference, St. Petersburg, FL, 1969.

"Health Physics Aspects of the Fission Product Inhalation Program", Western Industrial Health Conference, Las Vegas, NV, 1968. Co-authors: C. R. Richmond, R. G. Cuddihy, and R. O. McClellan.

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Radiological Emergency Operations (editor and contributor) for AEC by Reynolds Electrical and Engineering Co., Mercury, NV, 1967. (Many co-authors for this combined student text and instructors manual.)

Basic Nuclear and Radiation Physics, Defense Nuclear Agency, Albuquerque, NM, 1961. Co-authors: Otto G. Raabe and M. Edward Wrenn.

Principles of Radiation Detection Instruments, Defense Nuclear Agency, Albuquerque, NM, 1960. Co-author: William Lynch.

Many reports have been written for customers through consulting work. These include:

Annual Reports of environmental surveillance results for nuclear power plants. Four reports were a detailed summary of multi-year baseline or pre-operational data.

Environmental impact statements and assessments for uranium mills, heap leaching, and solution mining operations.

Pre-operational monitoring summary reports for special Nuclear fuel plants.

Extensive, multi-volume, health physics procedures manual for the U.S. Navy.

Reports to oil and mining companies characterizing naturally occurring radionuclides at various sites.

## **COMMITTEES, OFFICES AND HONORARIA**

1993-96      American Board of Health Physics - Part I Examination Panel (Chairman - 1995 and 1996).



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- 1987-92 American National Standard Institute and Health Physics Society Committee to review/revise ANSI N 13.11 Standard for Personnel Dosimetry Performance - Criteria for Testing.
- 1989-91 New Mexico Radiation Technical Advisory Council.
- 1988-90 Continuing and General Education Committee of the Health Physics Society.
- 1983-86 American Board of Health Physics Preparation Courses. Rio Grande Chapter of the Health Physics Society. Organized and helped instruct three annual five-month courses for members preparing for Certification by ABHP.
- 1982-83 U.S. Environmental Protection Agency. Radiological Sampling and Analytical Methods for National Primary Drinking Water Regulations. Two year effort culminating in a Work Shop. Final report part of Analytical Methods for National Drinking Water Regulations.
- 1981-83 Chapter Council. Rio Grande Chapter, Health Physics Society.
- 1980 South African Association of Physicists in Medicine. Presented three of ten lectures for Uranium Health Physics Summer School in Pretoria.
- 1977-78 American National Standards Institute and Health Physics Society Committee to prepare ANSI-N-1978 Internal Dosimetry for Fission and Activation Products.
- 1974-77 Environmental Radiation Committee. Charter member of ad hoc committee led by Dr. James Watson, Univ. of North Carolina. Integrated to Environmental Radiation Section of the Health Physics Society.
- 1973-77 South Carolina Technical Education Committee. Committee directing programs at five state wide Centers offering Associate Degrees in Nuclear Engineering Technology.
- 1976-77 American Public Health Association. Co-authored chapter on Radiochemistry for Quality Assurance Practices for Health Laboratories (published 1978).

- 1976&71      American Industrial Hygiene Association. Chairman, Technical Committee on Ionizing Radiation.
- 1966            Secretary-treasurer, Lake Mead Chapter, Health Physics Society.

### **SUMMARY OF OTHER CONSULTING EXPERIENCE**

Environmental Monitoring program design, implementation, and assessment for uranium mills and solution mines, nuclear fuel plants, nuclear power plants, waste disposal sites, and government and industrial facilities. Modeling of predicted and actual source terms. Special problem studies.

Internal radiation dosimetry including correlation of inhaled/ingested material to bioassay data for the above client base plus physicians and attorneys. Routine and accident dose commitment determinations.

Remedial investigations and actions for local, state and federal facilities. Also for extractive industries and other corporations. Routine and emergency conditions.

Radiochemistry including new procedures, bench-top tests prior to major processing, quality assurance audits, identity of physical-chemical matrices containing contaminants, and establishment of analytical laboratories.

Shielding integrity studies for fuel reprocessing tanks, shipping casks, neutron poison panels, and large burst x-ray machines.

Neutron spectrometry including measurements and use of LOUHI and BON codes for data reduction. Nuclear power plants and a DOE facility.

Licensing assistance to uranium mills and for a broad scope of medical and industrial applications. Source materials licensing including unusual concentrations of naturally occurring radioactive materials in oil and mining industries. Included occupational and environmental controls, locations of specific source terms within processes, and disposal and stabilization of mixed (radioactive and hazardous) wastes.

Development of radiation detection systems ranging from field laboratories to special equipment to monitor unique problems.

Program reviews and audits for occupational and environmental health physics; exposure monitoring and control programs, radiochemistry laboratories, and procedure assessments. Follow-up after Technical Safety Appraisals and Tiger Team audits.

Special projects for a broad scope of operations. Examples include radon emanation from radium bearing construction materials, tracer radionuclides for process monitoring and enhanced oil recovery, alpha emitting contaminants in microchip manufacturing, and as an intermediary between industry and regulatory agencies.

Training ranging from basic health physics and radiation detection to specialized programs encompassing virtually all topics above. Regulatory compliance training has included elements of the new NRC 10 CFR 20 and DOE Orders including 5480.11, 5400.5, and 5400.6 and the more recent modifications within 10 CFR 834 and 10 CFR 835.